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A First-year Experience Impacting Graduation Rates for STEM College Students at an HBCU

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Abstract

A growing obstacle to our national goal of increasing the percentage of citizens with post-secondary degrees is low college completion rates, particularly among students from low-income and underrepresented populations. The persistence of low college completion rates for African American students, in particular, is an issue of national concern requiring targeted programs and initiatives to drive change. Historically Black Colleges and Universities (HBCUs) are critical in providing Black students access to higher education. However, completion rates at these institutions are often lower than at other higher education institutions. Nevertheless, focusing only on completion rates fails to account for the additional factors and successes of HBCUs. At Delaware State, an HBCU, the four-year graduation rate for first-time, first-year (FTFY) students is approximately 26%, while the six-year graduation rate is just below 40% in most years. Our institution is experimenting with programs to raise these graduation percentages, particularly for students in Science, Technology, Engineering, and Mathematics (STEM) majors. Here we present outcome data for a five-year project targeted at supporting FTFY students in their transition to college and improving their graduation rates. The project involved participants in a summer bridge experience that included an online introductory mathematics course, followed by engagement with a peer mentoring program throughout the first year. Our project showed immediate positive outcomes for participants' first-year retention, average GPA, and the number of course credits earned by the end of the first year (Harrington et al., 2016). Sufficient time has now passed to have six-year graduation rates for all five project cohorts, and the project appears to have effectively supported STEM students for improved graduation. The five-year and six-year graduation rates for the intervention cohorts were significantly higher than graduation rates for their peers in STEM and non-STEM disciplines. Over these five cohorts,

STEM students who participated in the intervention graduated at a significantly higher rate than their STEM and non-STEM peers and pursued post-graduate education at higher rates. Our results suggest that our project can serve as a model for improving retention and graduation rates for underrepresented students.

Introduction

In the US, the percentage of high school graduates entering college is much higher today than in the past, reaching about 70% in 2018 (Bureau of Labor Statistics, 2019), and the percentage of high school graduates who complete post-secondary degrees is also improving. About 63% of full-time, first-year students who started at four-year institutions in 2013 received a degree within six years of matriculation (NCES, 2021), compared to under 53% for 2009 graduates (Shapiro et al., 2015). Six-year graduation rates appear to be interrelated with the selectivity of the institution, from an average of 29% at open admissions institutions to 89% at the most selective institutions. At the same time, the NCES report also showed that only 33% of first-time, full-time students matriculating at two-year institutions received a degree within three years (2021).

The difference in college enrollment and graduation is particularly acute for students who are members of underrepresented racial and ethnic groups. While the percentage of students pursuing post-secondary education and successfully graduating has been steadily increasing, the percentage of students from underrepresented groups who complete their degrees continues to lag behind the completion rate for White students (de Brey et al., 2019; Flores & Park, 2013; Shapiro et al., 2018; Shapiro et al., 2017). The six-year graduation rate for high school graduates who entered four-year institutions in 2013 (the most recent cohort for which data are available) was 44.3% for Black students and 57.8% for Hispanic students, compared to 66.6% for White students and 76.1% for Asian students (NCES, 2021).

The persistence of low college completion rates for African American students is an issue of national concern that requires new initiatives and targeted programs to drive change. Historically Black Colleges and Universities (HBCUs) are critical in providing Black students access to higher education, equity, and support for degree completion (Bracey, 2017). These institutions have historically modeled cultural competency on individual and organizational levels, providing students with a culturally sensitive educational experience that is unparalleled in higher education. As such, enrollment at these institutions is sustained by students who attend HBCUs for the cultural enrichment, encouraging academic support, and the inclusive sense of community offered by these institutions (Carter, 2016; Rine et al., 2021). HBCUs provide access to higher education, with most accepting 50 – 90% of applicants (CCIHE, 2021). Inclusive admission policies provide college access and equitable opportunities for a wide range of students, which has a tremendous positive social impact; however, accepting less prepared students can result in lower graduation rates (Blom et al., 2020).

While a comparison of six-year graduation rates for Black students shows completion rates of 32% at HBCUs compared to 45% at predominantly white institutions (PWIs), focusing only on completion rates fails to account for the additional factors and successes of HBCUs (Nichols and Evans-Bell, 2017). Several recent studies have shown that when compared only against institutions serving similar student populations, HBCUs have higher success rates for college completion among Black students than PWIs. A study comparing 105 HBCUs to 675 non-HBCUs found significant differences in graduation rates. However, when the authors limited the comparison to 38 HBCUs and 294 non-HBCUs for which low-income students made up between 40% - 75% of first-year enrollment, the average six-year graduation rate for Black students was 32% at the non-HBCUs compared with 37.8% at HBCUs (Nichols & Evans-Bell, 2017). Another study selected 10 HBCUs and 10 PWIs matched by selective sampling based on the following variables: the size of the student population, geographical location, institution type (public or private), and student socioeconomic factors. The researchers found that the HBCUs performed equally well as the PWIs in graduating African American students (36% for HBCUs and 39% for PWIs) even while the overall graduation rate for all students at HBCUs (35.7%) was lower, on average, compared to the matched PWIs at 49.7% (Montgomery & Montgomery, 2012).

Another study comparing HBCUs to PWIs for student outcome variables adjusted for pre-college characteristics (e.g., SAT scores and eligibility for Pell grants). That study compared 96 HBCUs and 96 PWIs matched by size, geographic location, and institution type (public/private) using data from the US Department of Education. There was a significant difference in overall graduation rates for HBCUs and PWIs, 30% versus 48%, respectively (Hardy et al., 2019). However, when the comparison was adjusted by percent of students who were Pell grant recipients and students' average SAT scores, graduation rates between the HBCUs and PWIs were not significantly different. These results suggest that HBCUs are leading institutions in supporting successful engagement, matriculation, and graduation for the broadest groups of underrepresented students. Nevertheless, there are substantial disparities in graduation rates for African American students and those from other underrepresented groups compared to national averages. Meeting the national goal of increasing the number of citizens with post-secondary degrees will require increasing the graduation rate for students from all backgrounds attending all types of institutions.

Opportunity equity is a major factor in lower educational attainment for students from low-resourced and underserved communities, such that racial and ethnic minorities, low-income students, and those from urban or rural under-resourced high schools are more likely to enter college underprepared and thus require additional academic and social support to succeed (Davis & Palmer, 2010; Melguizo, 2008; Nix et al., 2021; Perna, 2005; Rose & Betts, 2001). Parental expectations of students and involvement in students' course selection, as well as parents' educational attainment, social capital, and socioeconomic status, are factors that impact students' decisions to enter college and major in a STEM field (Bottia et al., Moller, & Parker, 2015; Mau & Li, 2018; Meador, 2018). Opportunities to engage in STEM-related programming, summer camps, and courses; teacher support and expectations; and student sense of belonging and identity are additional variables that drive college preparation for STEM majors. Lack of access to academic resources, educational opportunities, and high school course selection, particularly regarding mathematics, significantly impacts students' decision to pursue STEM majors in college. For instance, Calculus I is the required first-year mathematics class in many STEM programs. The declining number of students equipped to succeed in college-level calculus during their first year reduces the pool of students likely to graduate with STEM degrees in four years (Bahr, 2010; Bowen et al., 2019; Kreysa, 2006). Additionally, lack of college readiness due to opportunity inequity impacts student success, as those who enroll in remedial classes are far less likely to complete degrees, and the lower the initial placement, the less likely a student, is to obtain a degree (Bailey et al., 2010; Martorell & McFarlin, 2010; Jeffrey C. Valentine et al., 2017). While institutions have traditionally placed students in developmental classes to close opportunity and achievement gaps in mathematics, studies of large samples of college students have not found clear evidence that assignment to remedial mathematics courses provides benefits for academic outcomes, suggesting that alternative approaches are needed to help these students achieve success (Boatman & Long, 2018; Bowen et al., 2019; Melguizo et al., 2016; Ngo, 2019; Quarles & Davis, 2017; Jeffrey C. Valentine et al., 2017).

Peer mentoring has been noted as a best practice for increasing and broadening participation in STEM, and there is a growing understanding of the importance of successful mentoring for college success, particularly for students from underrepresented groups (Cutright & Evans, 2016; Doerschuk et al., 2016; Morales et al., 2016; Zaniewski & Reinholz, 2016). Mentoring in higher education is traditionally thought to be a relationship between an experienced faculty or staff member and a student facilitated by the faculty or staff. However, college students also form mentoring relationships with peers, friends, and near-peers such as graduate students (Crisp & Cruz, 2009). Since these relationships form organically and involve frequent interactions, fostering the development and cultivating the quality of peer mentoring can positively impact college students' success (Colvin & Ashman, 2010; Skipper & Keup, 2017). In addition, peer mentors may inherently possess a higher level of cultural humility, giving the protégé a safe space to develop the intersectionality of their identities, including that of a successful college student and scientist.

Moreover, peer mentors who are guided and trained are likely to engage in asset-based mentoring, drawing out the strengths of protégés in a manner relevant to their development as science students. The peer mentoring relationship also encourages the mentors' personal growth (Dennison, 2010; Falchikov, 2001; Shotton et al., 2007) and provides a sense of belonging, advice, support, and knowledge to the protégé (Colvin & Ashman, 2010; Lopez et al., 2010). HBCUs are good institutions for this type of intervention as the climate provides a supportive environment that values communal success (Gasman & Nguyen, 2014).

Our HBCU in the eastern United States enrolls a very diverse student body. Over 80% of students are members of underrepresented groups, and about 70% are African American. On average, over 50% of our undergraduates are eligible for Pell grants, and about 33% are first-generation college students. Our four-year graduation rate for FTFY students varies around 26%, while the six-year graduation rate is below 40% in most years. Our institution is experimenting with various programs to raise our four-year and six-year graduation rates closer to national averages, particularly for students in STEM areas, as these are signature programs at our institution. Here we present a case study of the Science and Mathematics Initiative for Learning Enhancement (SMILE) Project. The initiative was focused on increasing the success of FTFY students in STEM majors through their participation in a summer bridge experience and a first-year peer mentoring program. It involved five cohorts of first-year students from fall 2010 to fall 2014. The hypothesis underlying the program design was that providing academic and social support to improve academic outcomes and the first-year experience for students in their first year would improve retention and subsequently lead to higher graduation rates.

Mathematics and Student Success

One issue the SMILE program addressed was a troublesome introductory mathematics course. At that time, over 85% of FTFY students at our institution and more than 80% of FTFY STEM students were placed into a non-credit, developmental mathematics course, "Introduction to Algebra," based on the results of the Accuplacer™ placement exam administered to all first-year students. Nearly the entire first-year class was required to take developmental math as their first "college" mathematics course. Passing this course was required for students to advance into credit-bearing mathematics courses, which also serve as prerequisites for introductory courses in many STEM majors. Yet, many students repeated the course multiple times before earning a passing grade. Historically, pass rates for Introduction to Algebra ranged from 54% to 62%. In addition, the effectiveness of this course was questionable, as the pass rate for the subsequent credit-bearing mathematics course rarely exceeded 60%. This developmental course represented a formidable burden for both the University and its students.

To address this issue, the first two years of the SMILE program involved only mathematics review sessions as part of the summer bridge program to help students score better on the mathematics placement exam. Our formative assessment showed that the approach had no impact. In the third year, the program piloted providing incoming first-year STEM majors the opportunity to take the developmental Introduction to Algebra course online during the summer prior to their first year as part of a virtual summer bridge program. Based on the success of that pilot, the virtual summer bridge program was expanded to include a credit-bearing online college algebra course. Students were placed into the online mathematics courses based on the high school mathematics courses they completed, their performance in the courses, their SAT scores in mathematics, and the length of time since they took their last high school mathematics class. Most students were placed into college algebra even when their scores on the placement test would normally have placed them in the developmental course. None of the students in the program tested directly into a calculus class.

As reported earlier, the interventions showed immediate positive outcomes in 1) students' first-year retention and 2) the number of course credits earned by the end of the first year (Harrington et al., 2016). For both outcomes, data from the SMILE cohorts was compared to their STEM peers, who were not formally enrolled in the SMILE program. In the current work, we focus on graduation rates for the SMILE program cohorts compared to their STEM peers. Sufficient time has passed to make six-year graduation rates available for all five SMILE cohorts. The success observed in the first-year results predicted the overall project outcomes. SMILE cohorts significantly outperform their non-SMILE STEM and non-STEM peers in both five- and six-year graduation rates, suggesting that they left college with a deeper engagement with STEM. Our results indicate that our project can serve as a model for improving the retention and graduation of underrepresented students in STEM.

Program Description

Overall Objectives. The long-term goal for the SMILE project was to develop and implement effective interventions to increase the number of underrepresented students graduating from our HBCU with BS degrees in STEM areas.

The specific objectives of the SMILE program were:

1. To increase the first- to sophomore-year retention rate of STEM majors.
2. To build a sense of community among STEM students and increase their engagement with the University.
3. To increase the graduation rates of STEM students.
4. To increase the percentage of BS graduates who pursue advanced/terminal degrees in STEM.

To achieve these overall objectives, the program provided resources that assisted students establish a strong first-year GPA, improved the success of FYFT students in mathematics, and assigned peer mentors to help their student protégés achieve a sense of belonging. The SMILE project targeted STEM majors, including students majoring in agricultural science (environmental science, plant science, natural resources, or pre-veterinary medicine), biology, chemistry, computer science, information technology, mathematics, movement science/Kinesiology, and physics.

STEM Summer Training Camp

The SMILE first-year experience launched with a First-year STEM Training Camp held four to seven days prior to the fall semester; the duration varied by cohort. The goals of the program were to build skills in problem-solving, information literacy, and productivity software and to provide opportunities for relationship-building and engagement with fellow STEM majors and University faculty and staff. Skill-building sessions focused on mathematics, graphing, using spreadsheets, and analytical reading and writing. Sessions also involved hands-on activities designed to build reading, writing, and problem-solving skills, foster high-order thinking, and instill a growth mindset and other self-beliefs that have been shown to positively affect learning (Blackwell et al., 2007; Nesbit & Rogers, 1997; J.C. Valentine et al., 2004). Evening sessions featured motivational speakers and team-building exercises with faculty and peer mentors.

To help build excitement and engagement with STEM, the last full day of training camp was spent with students carrying out a research project in a small group under the guidance of a faculty preceptor. On the first day of the camp, students reviewed descriptions of potential projects presented by the faculty preceptors guiding the projects and made their selection for participation. Students were placed into groups of three or four by choice of project and given reading materials and pre-lab activities to prepare them for the project. Early in the morning on project day, students reported to the university labs to begin collecting data. After a mid-day break for lunch, students analyzed their data and prepared their group presentations. Students presented their work to faculty, peer mentors, and other students at the camp's closing dinner. Prizes were awarded based on the results, the appeal of the PowerPoint presentation, and the delivery of the oral presentation.

Virtual Summer Bridge Program

A major goal of the summer training camp was to help students enter a credit-bearing mathematics course rather than developmental mathematics. SMILE Summer Training Camp initially included mathematics review sessions before the students took their placement exams. Eligibility requirements for participation included: 1) commitment to enroll at the institution for the subsequent fall, 2) classification as an FTFY student for the subsequent fall, 3) declaration of a STEM major, and 4) completion of the Accuplacer™ exam for mathematics placement. Students learned about the intervention during information sessions offered during the University's New Student Orientation that students and parents attended together. Due to time constraints for program administration, only FYFT students who attended a New Student Orientation in the early summer were invited to participate.

The virtual summer bridge program placed students into the appropriate mathematics course considering placement exam results, SAT mathematics scores, and prior mathematics course completion. The online course was offered during the University's Summer Session II (in July-August). Students enrolled in these online classes had access to peer tutors who answered questions via email and cell phone during remote "office hours," held Sunday through Thursday evenings. Requirements for the courses included completing seven weeks of online material and instruction, followed by an in-person departmental common final exam administered during the STEM Summer Training Camp just before the fall semester.

For the first two SMILE cohorts, Summer Training Camp lasted seven days. After introducing the Virtual Summer Bridge, the Summer Training Camp was shortened to four days. The curriculum was updated to include a two-hour mathematics review session on the first day of camp to prepare students for the common mathematics final exam. The students then took the exam in person the following morning. All program activities, including the SMILE Training Camp and online classes, were fully supported by grant funding, and were offered to students without any financial obligation to the student. Top performing students in the online classes received book scholarships for the campus bookstore.

The Mentoring Program

The third major element of the SMILE program was a peer mentoring program for first-year students. Implementation of this component varied slightly every year with adjustments to training topics, the use of a performance incentive structure, and the addition of leadership development opportunities for peer mentors phased into the program. These changes were data-driven and informed by formal formative assessment and informal feedback from student participants.

Development and implementation of the peer mentoring program followed a cyclical process (Vela, 2014) that included pre-launch, program launch, program operation, and program evaluation steps on an annual basis. Pre-launch steps included clarifying institutional needs, identifying protégé's needs, recruiting mentors, and assessing mentors' training needs. The institutional needs identified during the initial planning for the SMILE program were derived from institutional retention and graduation data. They included increased STEM retention, enhanced academic performance in gateway courses, and improved graduation rates in STEM disciplines. Formal and informal interviews with faculty conducted as part of the formative assessment for the SMILE program indicated a need for improved class attendance by students, especially in early morning courses. Additionally, faculty indicated that they believed students could benefit from increased engagement with professors during office hours, ideally initiated by students, to prevent falling behind in STEM courses. Similarly, formal, and informal student interviews conducted during formative evaluation and training sessions suggested that there were needs for academic support from peers, role modeling for a successful transition into a college environment, a safe space for engaging in social and academic activity with peers and mentors, and opportunities for financial support during their undergraduate studies.

Mentor Recruitment and Training. The program defined peer mentors as students in STEM majors who had one to two years of seniority over the first-year students targeted by the project. Significant factors considered for selecting peer mentors included good academic standing, a strong GPA, and demonstrated ability to overcome adversity and recover from failure or setbacks. While the required GPA was 3.0, several exceptions were made based on evidence of an improving GPA with strong grades after the first year. After the first year, mentors were largely recruited from the pool of active SMILE participants from previous cohorts. Previous experience as SMILE peer protégés informed these peer mentors' approach to mentoring, enriching the mentoring relationship. The demographics of the peer mentors are shown in Table 1.

Table 1. Peer Mentor Demographics

	Cohort #1	Cohort #2	Cohort #3	Cohort #4	Cohort #5
Number	10	15	16	17	**14**
% Female	70%	67%	56%	76%	**72%**
% Minority	100%	87%	94%	100%	**71%**
% In-state	**31%**	**26%**	**28%**	**34%**	**39%**

Initial training for peer mentors took place over three days and focused on the role of peer mentors during SMILE Summer Training Camp for launching a strong peer mentoring relationship. During training, peer mentors developed team-building exercises that the entire SMILE cohort would participate in during the training camp. The mentor planning and training sessions also included allotted times for peer mentors to connect with their protégés a few days before their protégés arrived on campus. Throughout the academic year, a weekly peer mentor meeting with program leadership included additional training focused on helping peer mentors understand and develop interpersonal skills for fostering trust to engage in an effective and meaningful mentoring relationship.

Recruitment of First-year Participants. Participants were FTFY students in STEM majors at our institution who elected to enroll in the SMILE project. The project partnered with the office of admissions for the recruitment of incoming first-year students. Admissions informed incoming STEM majors about the opportunity to engage in the SMILE program as FTFY students and allotted the project team an opportunity to present detailed information during the University's break-out sessions at New Student Orientation. Here, information was presented to parents and students, onsite applications to the program were completed and collected, transcripts were requested from students and parents, and students made commitments to engage in the project. The student commitment included moving to campus a few days before first-year move-in day to attend the SMILE training camp and one year of participation in the SMILE peer mentoring program. In addition, parents were invited to attend the first day of SMILE Training Camp for a half-day orientation prepared for families of first-generation college students and the SMILE Training Camp celebratory dinner before the "Great Send Off" to college.

Participant Characteristics. Since the purpose of our SMILE program was to improve retention and graduation rates for STEM undergraduate students on our campus, we excluded from our analysis students who participated in the summer bridge activities. However, we did not matriculate in the fall (1 – 2 students in each cohort). Table 2 shows the breakdown of student participants by major, while Table 3 provides information about the demographics and entering qualifications of the SMILE cohorts compared to the overall population of FTFY STEM students in each cohort year.

Table 2. SMILE Participants by Major

	Cohort #1	Cohort #2	Cohort #3	Cohort #4	Cohort #5
Agricultural Science	6	4	7	6	**4**
Biology/Forensic Biology	27	25	14	18	**17**
Chemistry	2	2	6	6	**4**
Computer Science	3	6	-	6	**3**
Engineering/Physics	11	5	3	9	**6**
Food Science	-	-	-	-	**3**
Information Technology	8	1	-	-	**1**
Mathematics	4	1	2	-	**-**
Movement Science	-	3	3	1	**3**
Non-STEM	2	5	-	-	**1**
Total	**63**	**52**	**35**	**48**	**42**

Student participants in the SMILE project were required to be STEM majors upon entering the University. The non-STEM students included as SMILE participants are students who changed majors from STEM to another discipline after starting classes in their first year. The recruitment of participants was very broad, and all applicants who met the requirements for participation were accepted into the program.

In general, differences between SMILE cohorts and their congruent non-SMILE STEM peers were minor. Pooled t-tests were used to determine statistically significant differences in high school GPA and SAT verbal, and math scores using population means for the SMILE and non-SMILE cohorts. For some SMILE cohorts, there were statistically significant differences in pre-college academic profiles of the SMILE students compared to the overall STEM population, i.e., SAT scores for the first two cohorts in Fall 2010 and 2011 (Table 3). However, for the last three cohorts, pre-college academic profiles were not significantly different between SMILE and non-SMILE STEM students. A review of participant characteristics reveals that SMILE students were more likely to be female, minority, and out-of-state compared to the overall STEM population.

On average, SMILE students tended to have slightly higher high school GPAs than the overall STEM population, while their average SAT scores were similar.

Table 3. Demographics, High School GPA, and SAT Scores of SMILE Cohorts and the Overall STEM Student Population

	Cohort #1		Cohort #2		Cohort #3		Cohort #4		Cohort #5	
	SMILE	**STEM**	**SMILE**	**STEM**	**SMILE**	**STEM**	**SMILE**	**STEM**	**SMILE**	**STEM**
Number	63	133	52	176	35	207	48	187	42	**215**
% Female	62.3%	43.4%	71.4%	51.9%	88.4%	67.7%	69.2%	65.4%	73.2%	**59.5%**
% Black	83.6%	77.6%	85.4%	73.8%	86%	72.2%	84.6%	75.5%	90.2%	**76.3%**
% In-state	26%	32.1%	33.6%	35.7%	32.6%	36%	41%	40.5%	39%	**40.9%**
HS GPA Mean ± SD.	3.02 ± 0.53	2.88 ± 0.53	3.17 ± 0.51	2.99 ± .53	3.18 ± 0.44	3.04 ± 0.55	3.36 ± 0.44	3.09 ± 0.54	3.24 ± 0.51	**3.18 ± 0.55**
SAT Mean ± SD.	***921 ± 83**	**878 ± 102**	***910 ± 99**	**893 ± 106**	**907 ± 175**	**887 ± 208**	**882 ± 235**	**883 ± 220**	**899 ± 92.6**	**933 ± 119**

** Statistically significant difference ($p < 0.05$, t-test)*

Pairing Mentors and Protégés. Two methods for pairing mentors with protégés were used in the SMILE program. Initially, program participants were paired by academic majors. Peer mentors were selected at the end of the spring semester and initiated and maintained communication with their protégés throughout the summer. The assignment of mentoring pairs was solely based on academic major for the training camp and the fall semester. Thus, mentors were in the same or a very similar major as their protégés (e.g., pairing biology majors with movement science majors or physics majors with mathematics majors). Few changes were made in pairing, and major personality conflicts were addressed through mitigation by the SMILE Assistant Director, a few resulting in a new mentoring pair. Mentoring pairs remained the same throughout the academic year for the first program cohort. However, mentoring teams were reassigned for the spring semester using micro-interview sessions starting with the second cohort. Mentors and protégés held 3-minute interviews with each other and then selected their top choices for pairing. Mentors and protégés were matched so that everyone was paired with their first or second choice. Switching the mentor-protégé pairings for the spring semester helped students establish the practice of engaging in various mentoring relationships with different perspectives and personalities for a broader scope and more potential for growth (Geeraerts et al., 2015). Additionally, we observed that the first-year students relied heavily on their mentors during the fall semester as they transitioned into the college setting. However, as spring approached, engagement in the mentoring relationship decreased. Anecdotal evidence suggests new mentor-protégé pairings had a positive impact on engagement for the FTFY students in our SMILE program. Some of the original mentoring pairs continued informally after the change and were sustained in subsequent years.

The formality of the peer-mentoring relationship involved extended and continuous training for mentors and protégés; formalized agreements; guidelines for managing interpersonal relationships between students; and guidance for managing any student crisis that revealed itself through the mentoring process. Every peer mentoring pair developed mentoring agreements specifying the frequency of meetings, expectations, goals, and metrics for the relationship. Peer mentors attended weekly group debriefing sessions with the program staff, while protégés had monthly group check-ins with the program staff. Participant feedback involved interviews with mentors during mid-term performance evaluations and satisfaction surveys completed by protégés. There was also an end-of-term data collection that included interviews and questionnaires developed and administered by the external evaluator for the SMILE project. Subsequent progress was measured through relevant metrics, and program activities were adjusted based on feedback, performance, and best practices.

Expectations for Participants of the Peer Mentoring Program. On average, peer mentors spent 10 hours per week working on the SMILE project during the academic year. Recruitment of peer mentors for the following academic year occurred at the end of the spring semester. Peer mentors began their terms of service in the summer and conducted many of the leadership development and team-building activities during the training camp. Mentors signed agreements with the project for the academic year. They were evaluated after the fall semester, and agreements were renewed for the spring semester upon a satisfactory evaluation. In the first year, every peer mentor was assigned eight protégés, which proved overwhelming for the mentors, so the ratio was reduced to 5:1 for subsequent years. The fall semester proved to be much more demanding on the peer mentors' schedules than the spring, as the students were especially engaged in the mentoring relationship during the first semester transition from high school to university.

SMILE Study Hall. SMILE study hall became a central part of the mentorship program. Study halls were held every Tuesday evening from 8:00 pm to 10:30 pm and one Saturday every month from 1:00 pm to 4:00 pm for the entire academic year. All SMILE students were required to attend every session. During mid-terms and finals, SMILE also hosted an optional overnight study session that was well attended by SMILE and non-SMILE students. Initially, students were grouped with their mentoring teams for study hall and studied with their mentors. Peer tutors in every science area, as well as English and mathematics, were also available for study sessions during study hall. A program assistant was present at all study hall sessions and worked with mentors and tutors to improve student study habits, in general, as they studied specific subjects.

As the program progressed, some SMILE alumni from previous cohorts continued to attend study halls. Additionally, some SMILE students brought their non-SMILE classmates to study hall, and many participated regularly. As the semester progressed, study groups began to emerge in the study hall, and many of these groups met outside the study hall for additional study sessions.

Merit Pay for Mentors and Protégés. A unique and innovative component of our peer mentoring program was that the peer mentors received a service stipend plus bonus pay based on the academic performance of their protégés. Their base stipend was issued every semester they worked with the program. Performance compensation was issued at the end of each semester and structured around three performance metrics: 1) average GPA of the SMILE cohort (freshmen protégés), 2) average GPA of their mentoring group, and 3) ranking of their mentoring group by GPA. The performance bonus was tiered by GPA, and the maximum bonus was $2,000 per mentor, which required the mentoring group to achieve an average GPA of 4.0. Mentors of the best-performing mentoring groups received an additional bonus based on the average GPA of their mentoring group. The SMILE program also offered stipends to the first-year STEM students in the program based on GPA after the first semester. Students were awarded $500 for achieving GPAs of 4.0, and $250 was awarded to first-year students whose fall semester GPAs were above 3.0.

Data Collection and Analysis

Qualitative and quantitative data were collected and analyzed to measure students' perceptions of the importance of mentoring to their academic success. Upon enrollment, students who participated in the SMILE program were flagged in the University's student record system. Quantitative data for this study was provided by the University's Office of Institutional Research, Planning, and Analytics. The analysis included a Shapiro-Wilks test in determining normality; t-tests to determine significant differences between student cohorts for high school GPA, SAT verbal and math scores; and a follow-up report to compare GPA upon completing the bachelor's degree. A one-way ANOVA followed by a Tukey's Pairwise comparison of the SMILE cohorts determining significance for first-year data assessed GPA and credits earned. Chi-Square tests for homogeneity were used to test the significance of differences in graduation and graduate school enrollment rates. Qualitative data was gathered through surveys and focus groups.

Program Outcomes

Performance in Online Summer Mathematics Classes. The summer online mathematics courses began with cohort #3. The only course offered in this Virtual Bridge Program was Introduction to Algebra. A total of 35 students enrolled in the course and were placed into two sections with two different instructors. For cohort #4, course offerings were expanded to include College Algebra. This cohort consisted of 48 students. Accuplacer results placed ten students directly into College Algebra, and an additional 16 students were assigned to that course by program staff based on their mathematics qualifications. Twenty-two students who placed into

Introduction to Algebra by the placement exam remained in that course. The same instructor taught both courses with extensive online and hybrid teaching experience.

Mathematics placement results for cohort #5 indicated that all 42 students tested into Introduction to Algebra. Using the same SAT and high school course completion criteria as the previous year, 27 students were placed into College Algebra. The remaining 15 took Introduction to Algebra. The instructor and format for the courses remained identical to those for cohort #4. For cohort #5, two students did not complete the class and did not matriculate to the institution, while in cohort #4, one student did not complete the course and did not matriculate. Students who did not matriculate to the University were excluded from our analysis.

The distribution of grades for summer online classes for all SMILE cohorts is shown in Figure 1. During the first year, a substantial number of students did not complete the course. However, subsequent iterations included more technology support for students at the start of the course and increased availability of peer tutoring, which helped reduce the number of students who did not complete the courses. The performance of students in the online summer courses matched or exceeded that of similar students taking the same in-person classes in the fall. The passing rates for our online Introduction to Algebra classes were 80.8% for cohort #3, 75% for cohort #4, and 60% for cohort #5.

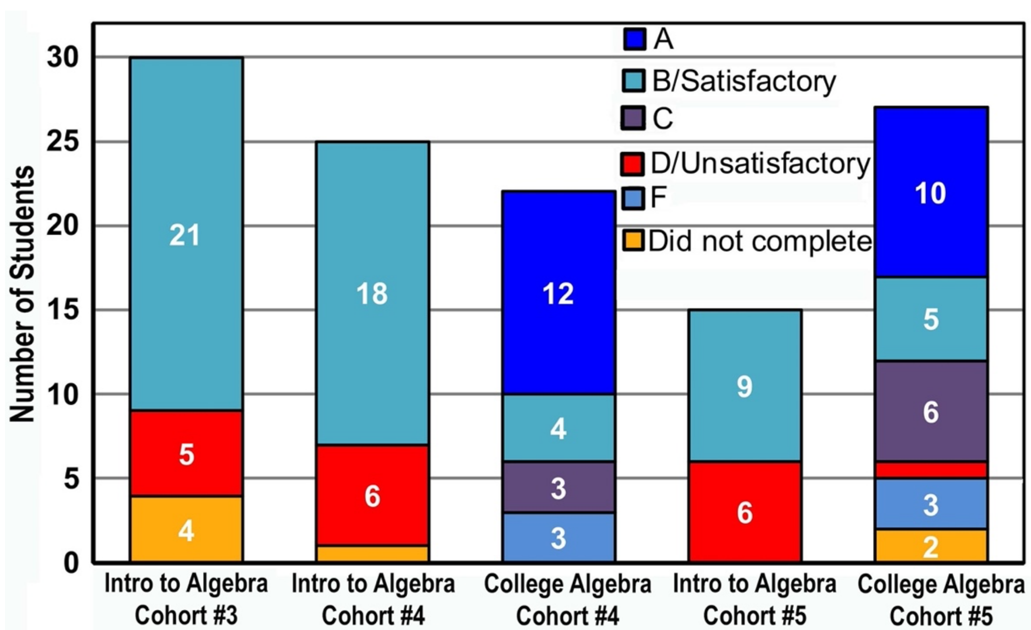

Figure 1. Distribution of Grades for Summer Online Classes for all SMILE Cohorts

In Intro to Algebra, students can receive grades of only “satisfactory” (green) or “unsatisfactory” (red), while students in College Algebra can receive the full range of grades. Data first reported in (Harrington et al., 2016).

In contrast, the average passing rate was 58.3% over three years for 1,499 first-year students taking Introduction to Algebra as their first mathematics course in the fall. For College Algebra, the passing rates for the summer online classes were 86% for cohort #4 and 78% for cohort #5. Contrastingly, over the same two years, the average passing rate for the 169 first-year students who took College Algebra in the fall was just 66.3%. *Grade distributions for summer online mathematics classes show that almost all students pass.*

Overall, analysis of the mathematics department's common final exam scores shows that students in the Virtual Bridge Program classes demonstrated the same or higher proficiency than students taking the same courses in person. Final exam scores for online courses equaled or exceeded the performance of students who took the courses simultaneously in a face-to-face modality. A comparison of mean scores for the common final exams for the SMILE online students across the three cohorts ranged from 58% - 62% for Introduction to Algebra compared to 56% - 59% for students in the face-to-face courses. Similarly, for College Algebra, the mean scores on the common final exam were 63% and 69% for the online course, compared to 64% and 68% for the face-to-face modality.

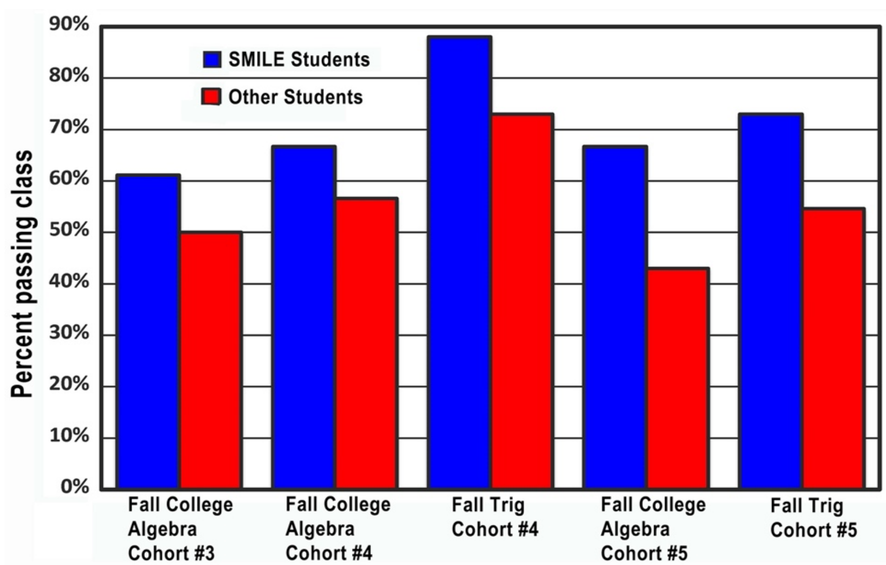

Figure 2. Students who took a summer on-line math class perform better than their classmates in subsequent mathematics courses.
The SMILE students (blue) all took an on-line class the summer before taking the class shown here. The "Other Students" (red) are students in the same course who did not take an on-line mathematics course. For cohort #3, n = 17 for SMILE students and n = 203 for all other students. For cohort #4 College Algebra n = 15 for SMILE students and n = 198 for other students. For cohort #4 Trigonometry (Trig), n = 16 for SMILE students and n = 108 for other students. For cohort #5 College Algebra, n = 9 for SMILE students and n = 328 for all students, for cohort #5 Trigonometry, n = 15 for SMILE students and n = 128 for all other students. Data first reported in (Harrington, Lloyd, Smolinski, & Shahin,et al., (2016).

Students who completed the online mathematics courses through the SMILE Summer Bridge Program also performed well in subsequent college mathematics courses they took on campus the following semester, passing at higher rates than other students. Most SMILE students who passed Introduction to Algebra in the summer took College Algebra in the fall, and most SMILE students who passed College Algebra in the summer took Trigonometry in the fall. As shown in Figure 2, a higher percentage of SMILE students who took an online summer mathematics class passed their mathematics course in the fall (College Algebra or Trigonometry) than students who had tested in these classes directly or who had arrived there by taking the prerequisites on campus in face-to-face courses. These results show that the SMILE students who took their first online mathematics course were as prepared for their subsequent mathematics course as those who came to the courses through traditionally taught courses.

First Year Outcomes. The primary objectives of the NSF-funded SMILE project were to increase first-year students to sophomore retention and graduation rates for STEM students at our university. Between their first and second-year SMILE, students were assessed for retention in the major, overall GPA, and credit hours accumulated. Those metrics were compared to the overall population of STEM freshmen.

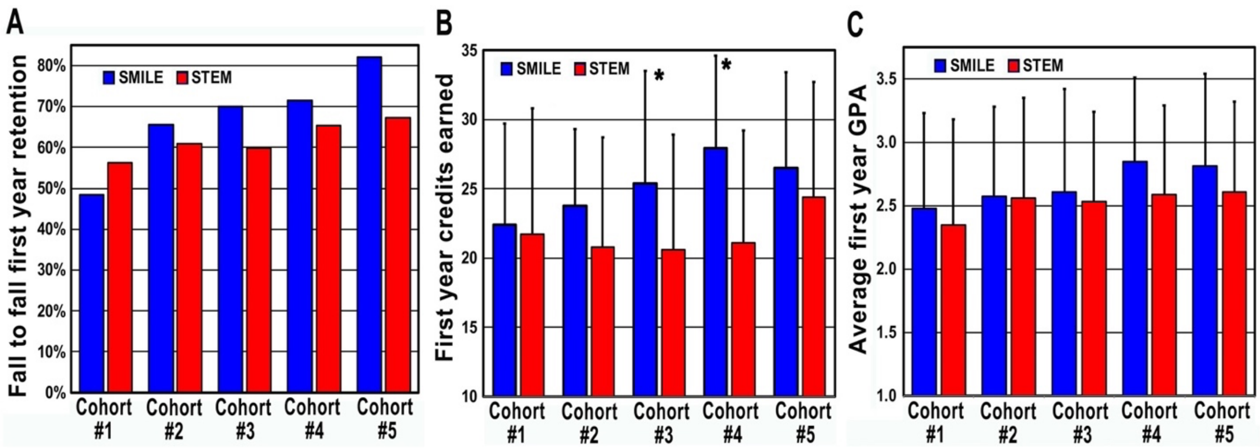

Figure 3: Overall first-year academic outcomes show SMILE students perform significantly better than the overall population of STEM students. A. First-year retention in the major. **B.** Average credits earned. **C.** Average first-year GPA.All were all calculated based on the first year, fall-to-fall numbers. GPA and credits earned are presented as means + S.D. Data first presented in Harrington et. al., 2016.

Cohort #1 - overall STEM n = 134, SMILE n = 64
Cohort #2 - overall STEM n = 179, SMILE n = 52
Cohort #3 - overall STEM n = 209, SMILE n = 48
Cohort #4 - overall STEM n = 192, SMILE n = 39
Cohort #5 - overall STEM n = 220, SMILE n = 33

In addition to the Virtual Bridge program, the SMILE program included a STEM Training Camp and a one-year intensive peer mentoring program. Training camp and peer mentoring began with the first cohort, while online summer classes did not begin until the third cohort. As shown in Figure 3 and Table 4, in general, students in the SMILE program were retained in their major at a higher rate than their STEM peers, accumulated more credits in their first year, and had slightly higher first-year GPAs. Positive outcomes of the SMILE program were evidenced for all; greater gains were recorded for the cohorts that took an online summer class (final three cohorts), particularly when that class was College Algebra.

Table 4: Statistical tests and outcomes for academic performance metrics for students in the SMILE program compared to non-SMILE STEM peers

Metric	Outcome
Retention	A *Chi-Square test of homogeneity* showed a significant difference in first-year retention for SMILE cohort #3 compared with non-SMILE STEM students ($c = 0.0019$, $p = 0.035$).
Credits earned	A *one-way ANOVA* showed a highly significant difference between SMILE cohorts and non-SMILE STEM students for credits earned in the first year [$F(9,1152) = 7.459$, $p = 0.001$]. A *Tukey's pairwise comparison* of the number of credits earned in the first year revealed a statistically significant difference between the populations for cohort #3 ($p < 0.05$) and cohort #4 ($p < 0.001$).
Cumulative grade point average (GPA)	A *one-way ANOVA* showed statistically significant difference in cumulative GPA [$F(9,1152) = 2.29$, $p = 0.015$] when compared with non-SMILE, STEM freshmen students. *Tukey's pairwise comparison* showed a significant difference in cumulative GPA for cohort #4 ($p = 0.043$) compared to non-SMILE STEM students.

Graduation Rates. The outcomes from the SMILE participants' first year were promising. An analysis of graduation rates confirmed that the intervention had a profound positive impact on student success in STEM degree completion. As shown in Figure 4, students who participated in the SMILE program graduated at higher rates than the overall populations of STEM students and non-STEM students at the institution. The difference is most variable for four-year graduation rates and most consistent for five- and six-year graduation rates. Interestingly, the four-year graduation rates between SMILE students, non-SMILE STEM students, and non-STEM students were not significantly different for any of the cohorts; however, five- and six-year graduation rates showed significant differences for these populations.

Additionally, in the aggregate, cohorts from the SMILE program and STEM peers in their graduating class finished their degrees with aggregate GPAs of 3.0 or higher, positioning these students to be highly academically qualified for their next endeavors (Figure 5). For some cohorts, SMILE participants' cumulative GPA at graduation was modestly lower than that of STEM students who did not participate in the SMILE project. Yet, the difference was not statistically significant for any of those years (one-way ANOVA).

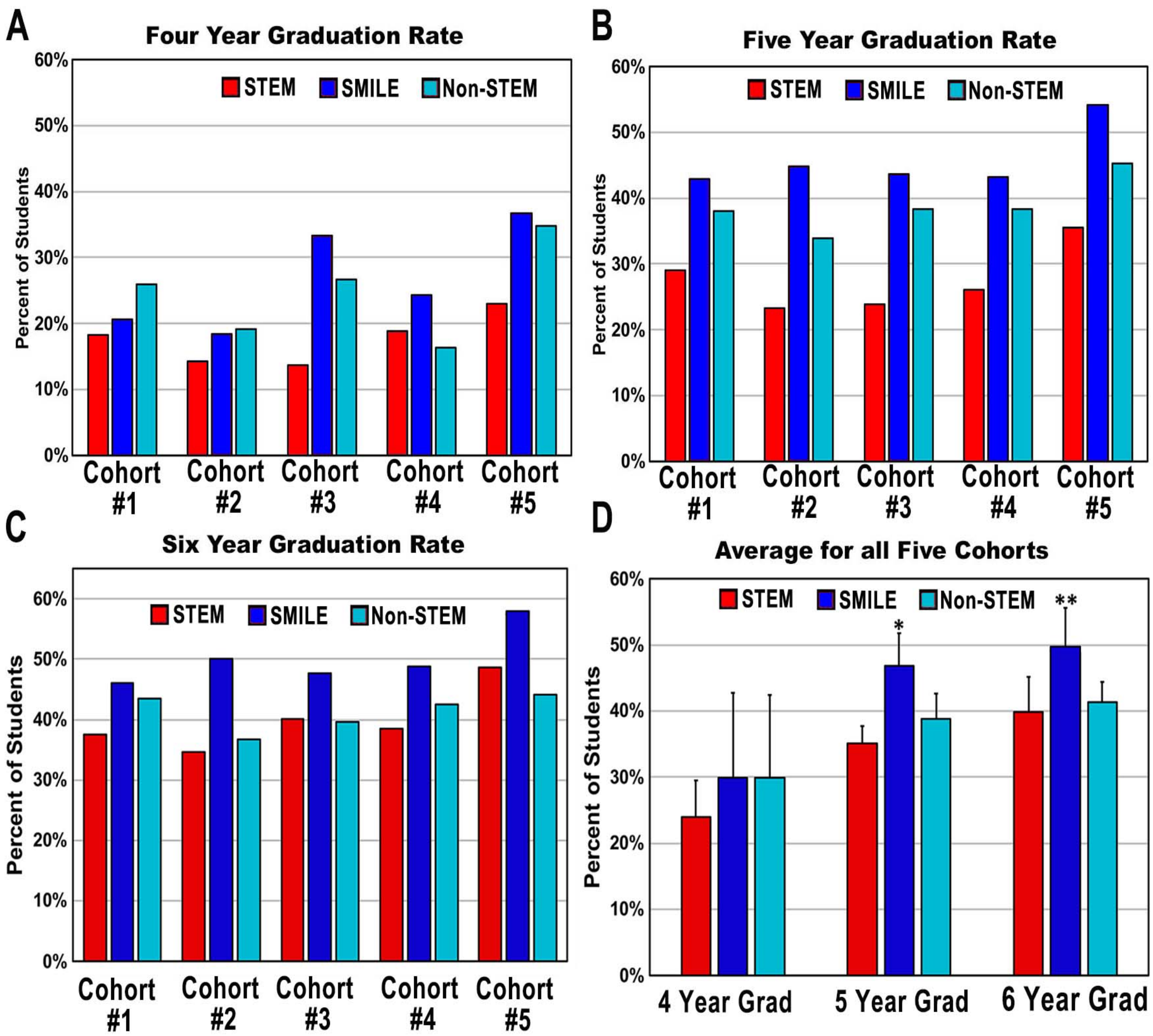

Figure 4: SMILE students graduate at higher rates than the overall population of STEM and non-STEM students.

A – C. graduation rates by cohort. **A.** Four-year graduation rates; **B.** Five-year graduation rates; **C**. Six-year graduation rates; **D**. Average graduation rates for all cohorts. five-year graduation rate, * Chi-Square test (c = 0.045, p = 0.022), six-year graduation rate, ** Chi-Square test (c = 0.0001, p = 0.001). **SMILE** = students participating in the SMILE mentoring program. **STEM** = non-SMILE students in STEM majors. **Non-STEM** = students in majors not eligible to participate in the SMILE program.

Cohort #1 size: SMILE = 63, STEM = 104, Non-STEM = 715

Cohort #2 size: SMILE = 52, STEM = 122, Non-STEM = 882

Cohort #3 size: SMILE = 42, STEM = 143, Non-STEM = 833

Cohort #4 size, SMILE = 39, STEM = 143, Non-STEM = 722

Cohort #5 size, SMILE = 33, STEM = 151, Non-STEM = 686

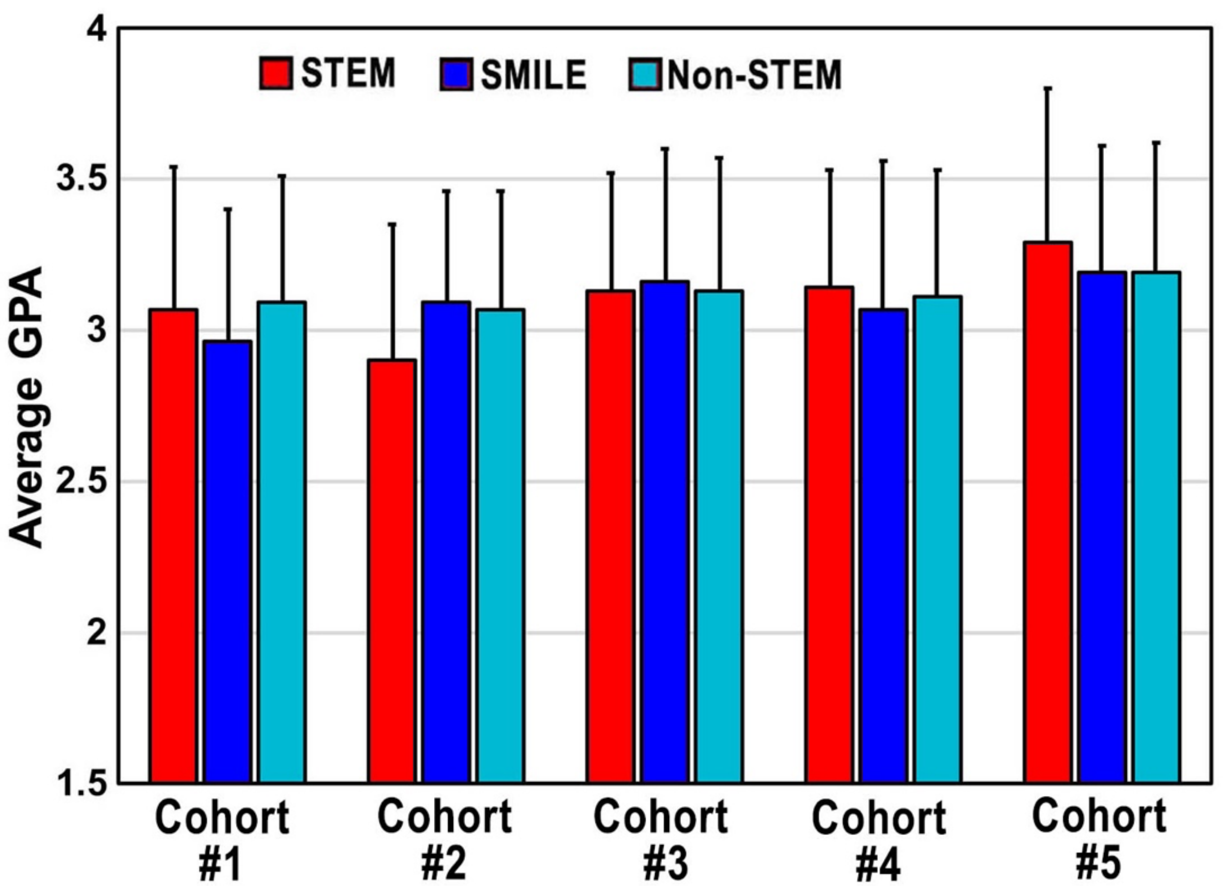

Figure 5: Cumulative GPAs at graduation for SMILE and non-SMILE STEM graduates are comparable. For each cohort of FTFY students, the cumulative GPAs of all cohort graduates were averaged, regardless of the year, they graduated. Data shown are the means + standard deviations for cumulative GPAs for all cohort graduates.

As shown in Figure 6, the total population of SMILE students, including all five cohorts, graduated at a significantly higher rate than the population of STEM students in those same years (Chi-Square test; c = 0.011, p = 0.006). In addition, a higher percentage of SMILE students graduated with a STEM degree, attended graduate school within five years of graduation, and attended a STEM graduate school than for the overall population of STEM students. This data is from the University's Office of Institutional Research, Planning, and Analytics.

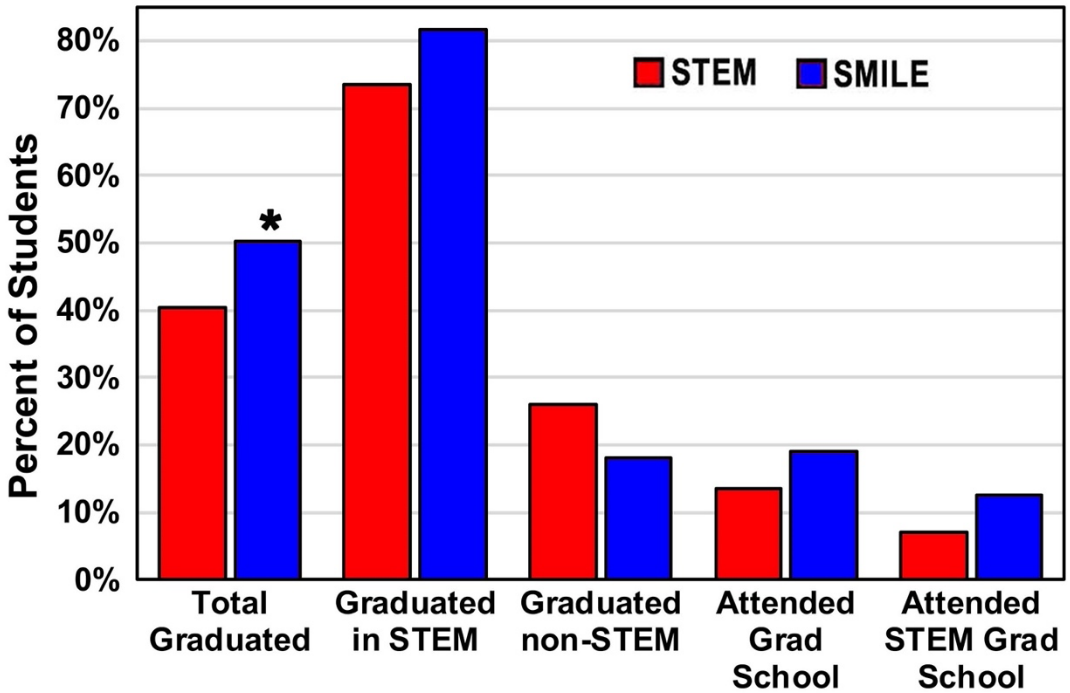

Figure 6: Graduation and post-graduate outcomes for SMILE and non-SMILE STEM students over all five cohorts. The "graduated" columns are the percent of students who graduated in all five cohorts comparing the population of STEM students to students in the SMILE program. Graduated in STEM and Graduated non-STEM show the percent of graduates who received a STEM degreeversus a non-STEM degree. Attended Grad School and Attended STEM Grad School show the percent of graduates who matriculated to post-graduate education, overall, and in STEM fields within three years of graduation.

Perceptions and Feelings About the Program. We were also interested in the participants' perceptions and feelings about the importance of the SMILE program to their academic success and professional development. Formative assessments were administered through surveys and interviews with all five cohorts, evaluating how student participants felt about the role of the SMILE program in their sense of belonging, the psychological meaningfulness of the project, and their satisfaction with project activities. The program's external evaluator administered the surveys annually, late in the spring semester. Figure 7 shows results for the final three cohorts that experienced the full program implementation, including the Virtual Summer Bridge program (online mathematics courses).

The results of surveys demonstrate that participants felt overwhelmingly positive about the experience and valued the SMILE program for their social and academic development. For these three cohorts, peer mentors were entirely or almost entirely selected from the pool of students who had participated in the SMILE program as peer protégés in earlier years. Among SMILE participants, more than 90% would recommend the SMILE program to other students, and by the spring semester of their first year, more than 45% had already done so. Similarly, more than 90% of students indicated that they would recommend the summer online mathematics courses to their peers. More than 85% felt that the program helped them navigate college and gain new skills, and over 80% felt that participating in peer mentoring as a protégé was important for their success.

During STEM Training Camp, students had an opportunity to engage with faculty frequently. Three faculty members served the program as engaged co-directors who were present and interacting with students. Training camp also involved an additional five to eight faculty members every year who led math review sessions and/or research projects. The evaluation shows that 90% of student participants felt the opportunity to interact with college faculty through the SMILE program was important to their success.

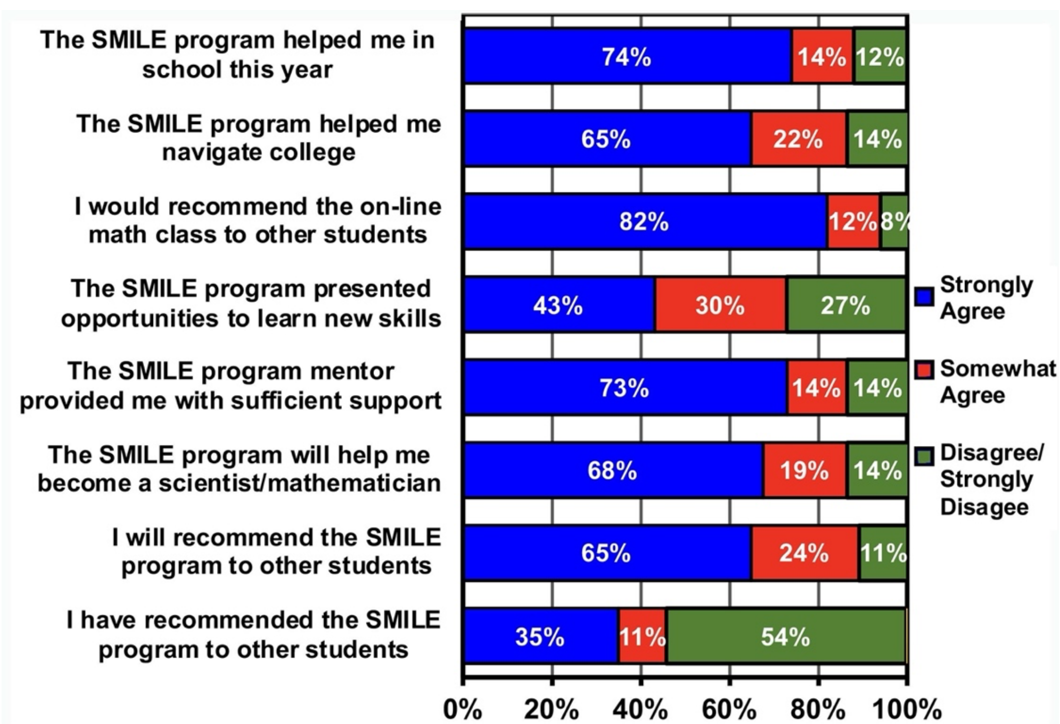

Figure 7. Results of student participant surveys regarding the role of the SMILE program in their success. Survey results for the final three cohorts. Survey respondents: Cohort #3 (n = 41), Cohort #4 (n = 35), Cohort #5 (n = 29)

Discussion

The SMILE program was designed to engage students during a critical time in their undergraduate experience. Participants benefited in their transition from high school to university by taking their first college mathematics course online during their pre-first-year summer in a highly self-sufficient yet supportive academic environment. Students in the online courses learned mathematics concepts independently and experienced the benefits of using homework and problem sets to understand mathematics concepts better. Our results from surveys and focus groups with students show that the online class guided them to develop habits and skills for independent learning that appeared to transfer to later academic courses. This program component took an asset-based approach to placing students in courses commensurate with their demonstrated academic proficiency in mathematics rather than relying solely on their performance on standardized and placement exams. Further, pre-pandemic teaching and learning online for nearly five years capitalized on students' capacity to engage technology in a sophisticated and productive manner.

The asset-based approach to teaching mathematics demonstrates a model for student success that challenges many historical or traditional methods for engaging underrepresented students in academic studies. Our outcomes for the online mathematics courses were much better than previously reported for underrepresented and underserved students taking online classes (Cottrell, 2021; Kaupp, 2012; Xu & Jaggars, 2014). The observed behaviors of students who took the online mathematics courses provide some insight into the successful outcomes of the participants, as observed by our experienced online instructor. SMILE pre-freshmen students exhibited more diligence and engagement with the course material than usual.

Most of the students in the SMILE courses completed all online assignments and viewed virtually all the online course content. This outcome was a striking contrast to other courses taught by this instructor, where students typically did only half of the assigned work and accessed only a fraction of the online material. The success of our students with online mathematics courses as a summer bridge program may suggest that differences in engagement in online courses based on the student's stage in matriculation may be a good subject for future investigation. The high level of engagement of pre-first-year students in online learning courses may be due to the focus given to the subject matter, as most students were not engaged in any other coursework during the summer. In addition, the excitement and novelty of college may have been an influencing factor for high levels of engagement. Their largely self-directed effort seems to have enhanced the students' success beyond their initial course, establishing a solid foundation in mathematics that increased their success in subsequent courses.

Students also benefited from mentoring relationships with experienced and successful STEM peers who helped guide them through their transition from high school to college and provided additional advice about succeeding in their respective disciplines. The gains made in the participants' first year are apparent and reflected in higher completion rates and more frequent graduation from a STEM major than the overall population of STEM students during the same years (Figure 3) and are consistent with outcomes observed for successful peer mentoring programs. Current literature suggests that this type of engagement on a university campus contributes to student satisfaction, belonging, and success (Thomas, 2012; Weber et al., 2013). This component intentionally supported peer mentors and protégés to develop their identity as student scholars and scientists while providing a safe space for students to embrace and develop the intersectionality of their identities. The space also aided in reducing stereotype threat as students became part of a community of scholars that defy the negative stereotypes that often impact identity and belonging.

We feel that two key elements were critical to the engagement of peer mentors in mentor-protégé relationships and the program: 1) Selection of student mentors based upon their demonstrated ability to overcome setbacks and prior experience in the program as protégés, and 2) Financial rewards based on the performance of the mentored students and cohort. The additional monetary awards to peer mentors were framed as a performance bonus. The incentive was very popular among the peer mentors, who expressed that the possibility of extra funding was critical in motivating them to go the extra mile to help their protégés. By the end of the first semester, we knew that the SMILE peer mentoring program differed from earlier iterations and designs of peer mentoring programs we had developed. The performance incentives and structured study hall appeared to create a positive dynamic. Other programs we have been involved in required administrative effort focused on ensuring that mentors and mentees met together regularly.

In contrast, a formative assessment of the SMILE program found that the mentoring relationships were, at times, nearly overwhelming for our peer mentors, requiring much more of their time than they had expected. In response to this issue, we added a component to our mentor training after the first semester to help mentors set boundaries in their relationships with protégés. Additionally, a bonus based on overall cohort performance encouraged mentors to support each other throughout the semester by helping with each other's efforts and mentees. The mentoring program became a "family" away from home for STEM students, for the mentors as well as their protégés, all supporting each other's success.

Increased interaction with faculty members outside of class was also an opportunity to give SMILE students a sense of belonging and enhance students' academic experience during their time at the University. The SMILE Summer Training Camp provided students with an opportunity to engage in small groups and one-on-one interactions with supportive faculty in academic settings that were exciting. Anecdotally, many of our students informally shared their high school experiences. From this communication, it seemed that many students experienced opportunity inequity in high school with limited interactions with teachers and other authority figures, consistent with previous studies (Jack, 2019). The SMILE Program began to address this power dynamic that serves as a barrier for many students who have experienced this opportunity inequity by facilitating positive interactions with faculty and staff. This reduced intimidation for some students who initially felt uneasy in personal interactions with professors and program staff. Surveys showed that SMILE participants valued this, and more than 90% of students said that it was an important part of the impact of the program.

Peer mentoring, family engagement, mathematics confidence and persistence, experiential learning, identity, belonging, overcoming stereotype threat, and many other factors affect success for underrepresented STEM students. In this study, we examined the impact of several interventions on the graduation rates of STEM students. Future research should also examine the impact of peer mentoring programs on the interpersonal, professional, and academic growth of targeted undergraduate STEM students. Anecdotally, both peer mentors and their protégés felt they experienced substantial growth in these areas. Additionally, as part of the recruitment of participants, this program engaged parents of first-generation students in an orientation to the institution and the students' college experience.

Our observations indicate that this intervention changed parents' expectations of their students (commuting home on weekends, family obligations, etc.); parents also stayed in communication with program staff, and some sent care packages to students via program staff. Future research examining the effect on student success of providing families of first-generation college students a deeper orientation to college might find that these activities have an impact. Another interesting area for future research that has particular importance with post-pandemic transitions to online course delivery is understanding the effects of virtual bridge programs on students' confidence and persistence rates in STEM. Finally, the format for the study halls implemented in this program provided a study and peer networking space that promoted the organic formation of peer study groups, many of which held additional study meetings outside the program. This model and its impact on study habits and GPA should also be examined. Many factors contribute to student success, and interventions that promote positive habits for first-year students could significantly contribute to their success.

Limitations

A significant limitation of our analysis is that it is difficult to determine the relative contribution to student success attributable to the various elements of the program since students participated in three major interventions: the virtual summer bridge class, the Summer Training Camp, and the peer mentoring program. There were also variations in cohort sizes and the number of students from different disciplines that reflected historical trends and institutional changes. Historically, biology has been the largest STEM major at the project site, and as such, biology majors were the largest group of students participating in the program. Cohort sizes tapered even as STEM enrollment in the institution grew. The required completion of the online mathematics course the summer before training camp as an additional condition for participation in the program may have contributed to a decline in participant numbers. Another consideration for the decline in cohort size is also related to university dynamics, including admissions recruiters and leadership changes. The availability of competing summer bridge programs offered to incoming first-year students at the University grew throughout the years the SMILE program was offered, which also may have hindered recruitment. Changes in SMILE project personnel may also have affected the peer mentoring team's perceptions and attitudes towards the program, particularly for the fifth cohort when there was a change in program personnel. It is critical to consider that internal and external factors affected students and the program during the five years of implementation.

Another limitation of analyzing the study results includes the involvement of non-SMILE STEM participants in the SMILE Peer Mentoring Program components. Students who were not engaged in the formal program, and were not assigned a formal mentor, often participated in program activities as guests of their STEM peers and formed informal mentoring relationships with program participants. Therefore, the comprehensive reach of the SMILE program is difficult to assess, given its potential impact on the "control group" for this study.

Conclusion

While this case study of our program has limitations, the impact of our SMILE program on the retention and graduation rates of STEM students from underrepresented groups makes it significant. It is notable that peer-reviewed literature regarding the impact of peer mentoring programs focused on undergraduate STEM students is sparse. The field would benefit from more studies of peer mentoring programs and improved dissemination of successful models, given that increasing college graduation rates, particularly for students from underrepresented groups, is a national priority. Improving diversity and enhancing inclusive practices by implementing asset-based interventions through every juncture of the STEM pathway has the potential to improve the national economy, science, and innovation.

Successful peer mentoring programs require clear objectives, intentional design, and deliberate structure. In our experience, an impactful academic mentoring program design requires a degree of flexibility to remain student centric. It must maintain the option to adjust program components based on the formative assessment. Thus, engaging students in these assessments and creating a safe environment to express their needs, observations openly, and experiences is critical to successful programming. It is also important to seriously consider the feedback given by students and make timely changes to programming.

Both protégés and mentors require training and support to engage in a successful peer mentoring relationship. Guiding students to set expectations for each other and mentoring engagement are necessary to give students ownership of their partnership. A unique element of our program was that it supported the mentoring cohorts' academic success through a funding structure that rewarded mentors for the cohorts' academic performance. This program characteristic encouraged high levels of engagement and improved academic performance for protégés and mentors. This incentive proved very successful. Results from our study reveal that participation in our peer mentoring program was related to higher graduation rates for undergraduate student populations majoring in STEM disciplines, and anecdotal evidence suggests that mentors benefited from the relationship.

Identity, belonging, and engagement impact student performance in STEM. Creating a safe space for the development of the students' intersectionality of identities is important for promoting students' sense of belonging and identity as scholars and scientists. All college students benefit from networking and identifying with peers and faculty. Some students from under-resourced high schools or first-generation college students who have had limited or negative interactions with authority figures benefit from facilitated positive interactions with faculty as they begin their college experience. Interventions that intentionally address this can have a meaningful and positive impact on students, their identity in STEM, and their experience as scientists in training and beyond.

The mathematics course offered in the summer before the students' first year also impacted our observed graduation rates. Proficiency in mathematics is required for success in STEM majors, yet many of our students did not place into College Algebra their first year. There are many reasons for this: the placement examination model: the timing for administering the placement exam; lack of preparation for the exam; lack of communication about the gravity of the exam; high school course selection; high school counselor recommendations; lack of parental understanding of how to leverage high school education for college success, especially for first-generation college students opportunity equity and selection of classes in high school; and many other barriers. The asset-based approach and implementation of the virtual summer bridge intervention removed and compensated for some barriers students faced prior to their first year. It seemed to be effective in accelerating students' achievement in STEM.

The SMILE Program implemented several interventions that together successfully impacted student graduation rates. Program components were interrelated in a multi-pronged approach for student success, and the participants benefited from the collection of interventions. The multiple interventions supported student engagement and academic performance, improved the student experience, and led to higher graduation rates among a largely African American population. Our results suggest that our project can serve as a useful model for improving the retention and graduation of underrepresented STEM students at other institutions.

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